Modular Magnetic Mobile Manipulators for Microgravity Environments

Completed Technology Project (2013 - 2015)

Project Introduction

The proposed research utilizes novel omnidirectional electromagnets capable of on-line reconfiguration, called Omnimagnets, currently in development at the University of Utah. An Omnimagnet is a cube with no moving parts, capable of real-time control of the magnitude and orientation of its magnetic field. If a magnetic tool is introduced in an Omnimagnet's magnetic field, the Omnimagnet can dexterously manipulate the tool's position and orientation. This method of manipulation is unlike any other telerobotic manipulation technique. In space, Omnimagnets will be able to manipulate each other and their separate magnetic tools, utilizing magnetic forces and torques that go beyond simple attraction and repulsion. By fixing to various spacecraft or satellite surfaces, Omnimagnets can walk across surfaces and magnetically carry tools large distances, using inchworm inspired approaches. Thus, Omnimagnets can deliver tools to the worksite and then manipulate those tools, potentially enabling safer and more cost-effective procedures. Satellite repair, debris removal from convoluted hard-to-reach structures, and assembly of structures in microgravity are some of the challenges that Omnimagnets and their tools will tackle in space. Like other manipulation systems operating in space (e.g., Robonaut 2, SmartSPHERES), Omnimagnets will be able to relieve astronauts of both tedious routine maintenance tasks and highly dangerous extra-vehicular activity. Magnetic manipulation and inchworm locomotion in microgravity is a unique approach to coordinated motion that may contribute to other mobile manipulation projects. The design is also modular, allowing for Omnimagnets of various sizes and attachment mechanisms to work together to manipulate a diverse set of tools in a variety of environments. Furthermore, Omnimagnet manipulation will be safe for operation with and around humans, with no internally moving parts, low forces, and slow manipulation speeds. This project will involve: (1) the development of models and simulations of multiple Omnimagnets in a variety of manipulation scenarios; (2) the design and construction of a set of Omnimagnets, as well as a tool for the Omnimagnets to manipulate; (3) the development of a localization method for the Omnimagnets and their tools based on magnetic and range-finding techniques; (4) the construction of an aquarium to simulate microgravity, and attached air-filled containers to make the Omnimagnets and tool neutrally buoyant; (5) the experimental demonstration of manipulation techniques with the set of Omnimagnets and the tool using direct telemanipulation; and (6) the algorithm development and experimental demonstration of supervised autonomous control, in which the low-level Omnimagnet control is handled in software to achieve the human user's desired high-level commands.

Anticipated Benefits

Satellite repair, debris removal from convoluted hard-to-reach structures, and assembly of structures in microgravity are some of the challenges that Omnimagnets and their tools will tackle in space. Omnimagnet manipulation

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Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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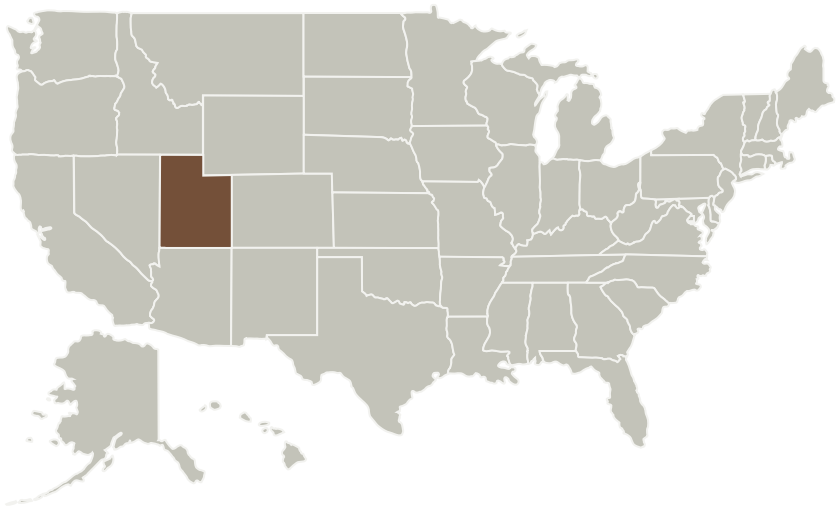
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Utah	Supporting Organization	Academia	Salt Lake City, Utah

Primary U.S. Work Locations
Utah

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Project Management

Program Director:
Claudia M Meyer

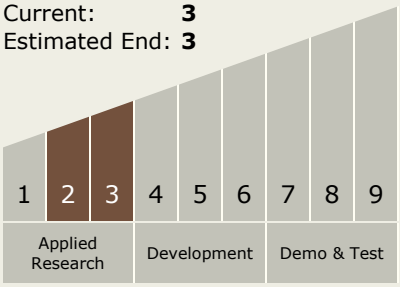
Program Manager:
Hung D Nguyen

Principal Investigator:
Jake Abbott

Co-Investigator:
Joseph B Brink

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.3 Simulation
    - TX11.3.5 Exascale Simulation